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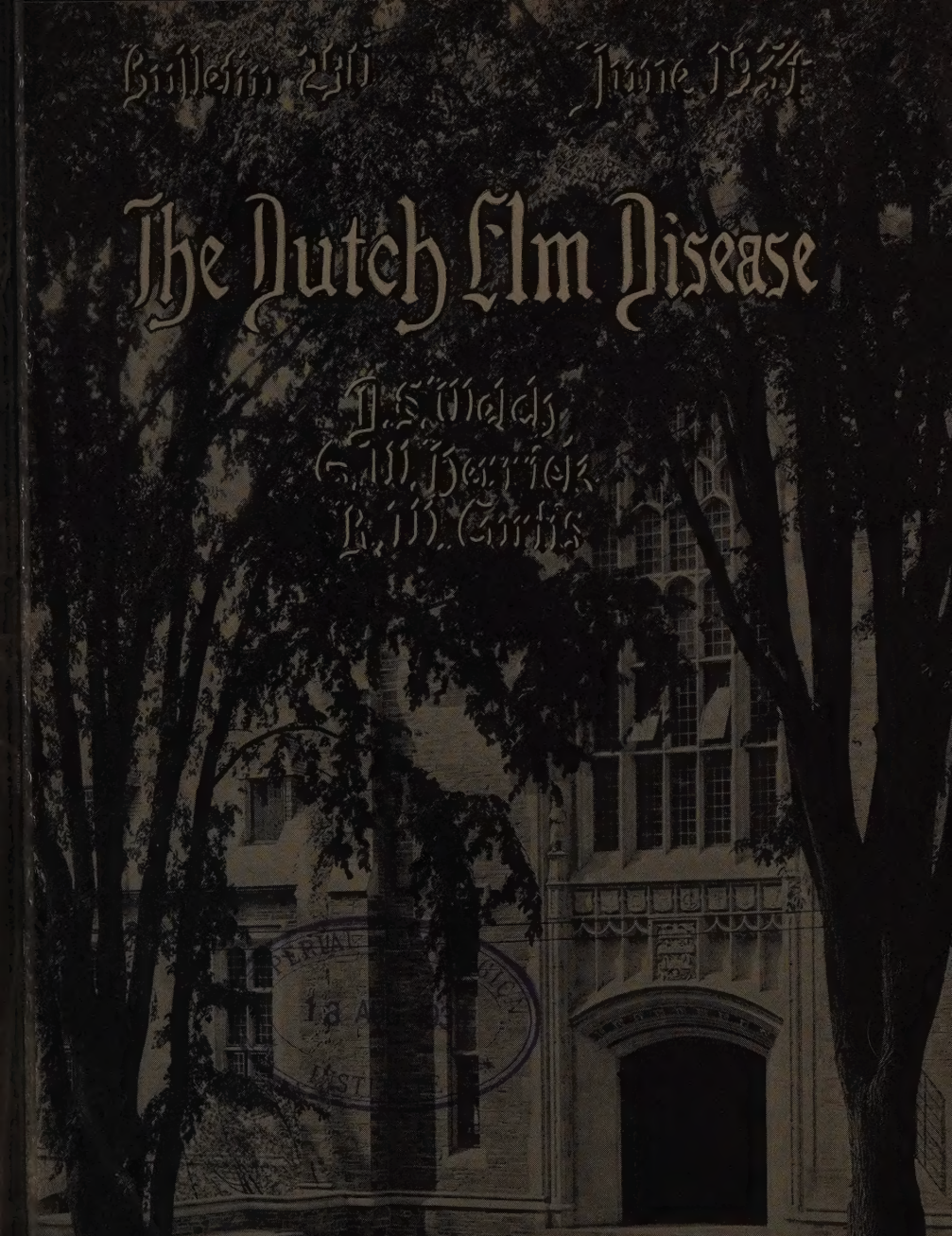

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THE DUTCH ELM DISEASE

D. S. Welch, G. W. Herrick, and R. W. Curtis[1]

The American elm (*Ulmus americana* L.) and its varieties is without doubt our most valuable shade and ornamental tree as well as being of considerable importance in the forest. Growing, as it does, from the East Coast to the Rocky Mountains and from Canada as far south as Texas, the elm is distinguished by its stately character and beauty of form. In the East, particularly in New England, New York, and New Jersey, many cities and towns are noted for the beauty of their elms. It is impossible to visualize or to estimate what the loss of these trees would mean to such communities.

With the recent discovery (1930) of the destructive Dutch elm disease in the United States, and its subsequent history in New York and New Jersey, the elms are threatened with possible extermination or at least severe injury comparable to that which has already occurred in Europe. This recently introduced disease has received considerable attention through various channels, and an intense public interest has thus been aroused. It is the purpose of this publication to present a brief and concise discussion of the several aspects of the disease, with suggestions for coping with it.

HISTORY OF THE DISEASE IN EUROPE

The disease under consideration was first discovered in Holland in 1919 and hence received a somewhat misleading name, the *Dutch elm disease*. It is by no means restricted to the Dutch elm (*Ulmus hollandica* Mill), and there is no evidence that it originated in Holland, although the length of time the disease may have existed in that country prior to 1919 is not known. During 1920 the disease became increasingly severe in Holland, and by 1921 had spread over Belgium and into northern France. The first report of its presence in Germany was received in 1921, and by 1924 the damage was severe and widespread in various parts of that country. Infected elms were reported from Norway in 1926 and from England in 1927. Thus in the space of but a few years, the Dutch elm disease has swept through Holland, Belgium, France, and into northern Italy. It has spread from Germany to Norway, Sweden, Poland, Switzerland, Austria, and certain of the Balkan States. In other words, the disease is now widespread over the European continent and in England.

In many of these countries, the elms have been practically exterminated. The famous elms in the avenues at Versailles are a total loss, and similar

[1] Assisted by C. E. F. Guterman, L. H. MacDaniels, E. L. Worthen, R. S. Hosmer, and D. Wyman.

cases of destruction have been reported from Holland and Germany. The disease appears to have been somewhat less destructive, thus far, in Italy and England. The Dutch elm disease became increasingly severe in England between 1927 and 1931. During 1932, there appeared to be a definite check in its progress, with another increase in 1933. In spite of the increase, however, the disease was not so severe as in 1931. Also, recoveries of infected trees have been reported from England.

PRESENT STATUS OF THE DISEASE IN THE UNITED STATES

It was not until 1930 that the Dutch elm disease was first reported in this country. Four trees infected with the causal fungus were discovered that year in Ohio. In 1931, four more trees were found in Cleveland, Ohio. All of these diseased trees were destroyed by federal and state workers, and the disease was believed to have been eradicated from that area. This belief was supported by the fact that no new infections were discovered in 1932.

In June, 1933, however, a severe outbreak was discovered in New Jersey, and a few weeks later infected trees were discovered on Staten Island and Long Island, and in Westchester County, New York. This outbreak, having as its center the Port of New York, was entirely separate from the one in Ohio. On March 1, 1934, approximately 1200 confirmed infected trees had been discovered. While most of these were in New Jersey, about 150 were in lower New York State, especially in Westchester County. Aside from the diseased trees in New Jersey and New York, one infected tree was found during the summer of 1934 in each of the following States: Connecticut, Maryland, and Ohio.

Until recently, the mode of entrance of this disease into the United States has remained obscure. In the summer of 1933, however, considerable evidence was obtained by federal pathologists to the effect that the fungus gained entrance on elm-burl logs imported from France for use as veneer in the manufacture of furniture. Such logs were found not only to be infected with the fungus which causes the Dutch elm disease but also to be infested with the two common European species of bark-beetles known to be carriers of the organism. The further importation of such logs with the bark attached is now prohibited by a federal quarantine. With the bark removed there is no danger of importing further insect vectors, or carriers. The fungus, if present, will be killed by the steaming which the logs undergo prior to their being sliced into veneer.

SUSCEPTIBILITY OF SPECIES AND VARIETIES OF ELM

Since about 20 species of elm are native in the Northern Hemisphere, not to mention innumerable horticultural varieties, it seems reasonable

to expect that some forms might possess resistance or immunity to the disease. Extensive trials to test trees for their susceptibility have been made in several European laboratories, especially in Holland and Germany. The results have shown that most of the species and varieties tested are rather easily infected. The Asiatic species *Ulmus pumila* L., and its variety *pinnato-ramosa* Henry, appear to be resistant. Other forms which have given some promise are the Exeter elm (*U. glabra* var. *fastigiata* Rehd.) and the Chinese elms (*U. parvifolia* Jacq. and *U. Wilsoniana* Schneid.).

Cases of apparent resistance have been observed in individuals of normally susceptible species like the English elm (*Ulmus campestris* L.), the American elm (*U. americana* L.), and the smoothleaf elm (*U. foliacea* Gilib.). It is possible that further investigation of various forms and varieties of these and other species may discover desirable individuals or strains from which a resistant or immune stock can be grown to supplant the trees killed by disease and for new plantings.

SYMPTOMS OF THE DISEASE

The first indication of the Dutch elm disease is usually a wilting of the leaves on one or more branches of the tree (figure 1). This is most likely to take place in early summer, although it may occur as late as August. The leaves become dull green and remain clinging to the twigs in a dried and shriveled state, or they turn yellow or brown and remain attached or fall from the tree. The end leaves may persist on affected twigs after the others have fallen, and the tips of dead twigs curl in a characteristic manner. In winter the disease manifests itself mostly by these curving tips and by numerous suckers on the trunk at the bases of the larger branches. In early spring there is added to these symptoms a late and sparse development of abnormally small leaves.

Entire trees may be affected and killed suddenly during a single season, but the disease usually persists for several years, each yearly development being more severe. Such trees gradually assume a sickly appearance, their growth is slow, and the foliage remains sparse and small. In the later stages, whole branches may die and gradually decay and break off. This usually happens in the top of the tree, giving rise to the "stag-headed" appearance.

The symptom of most value in the field diagnosis of the Dutch elm disease is seen in the sapwood of dying or recently killed branches. When such branches are cut crosswise, brownish discolored spots or flecks show in the wood near the bark, usually in the form of one or more broken rings (figure 2). A long slanting cut with a sharp knife in a similar twig will reveal irregular brownish streaks (figure 3). By stripping the bark from

PHOTOGRAPH FROM R. P. WHITE, NEW JERSEY AGR. EXP. STA.

FIGURE 1. AN ELM TREE SHOWING WILTING AND VARIOUS STAGES OF DEFOLIATION

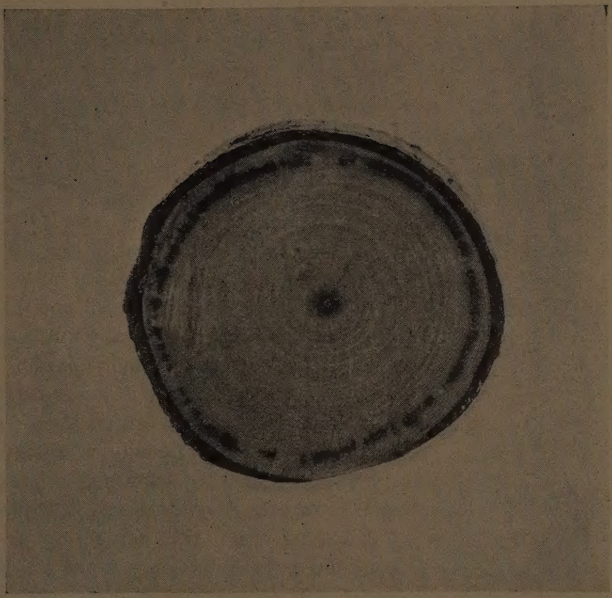

FIGURE 2. CROSS SECTION OF A BRANCH AFFECTED WITH THE DUTCH ELM DISEASE, SHOWING BROWNISH DISCOLORATIONS IN THE SAPWOOD

young, recently affected twigs the same brown streaks may be seen running in longitudinal direction just under the bark.

Well-established trees between the ages of 15 and 40 years are most frequently attacked, but young nursery trees and mature individuals of advanced age are often severely affected. Trees may be diseased without showing clearly any of the symptoms mentioned. Certain trees with abnormally small and very pale green leaves, showing no wilting or death of parts, may exhibit the discoloration in the wood on cutting.

Other similar diseases of the elm

Under most conditions absolute identification of the Dutch elm disease in the field is impossible because several other diseases of the elm are characterized by identical field symptoms. Such diseases as the verticillium wilt or the die-back caused by Cephalosporium can be distinguished from the Dutch elm disease only by means of a laboratory test, during which the fungus is obtained from the diseased wood and grown in artificial culture where it may be recognized. A bacterial organism has been described in Europe which causes brownish streaks in the sapwood of elms. For

FIGURE 3. LONGITUDINAL SECTION OF TWIG REVEALING DISCOLORED STREAKS IN THE WOOD

positive proof that a tree has the Dutch elm disease it is therefore necessary that suitable specimens be sent to some laboratory equipped to do the necessary work of identification.

Precautions in selection of specimens for diagnosis

If a tree is suspected of having the Dutch elm disease and a confirmation is desired, the following directions should be observed. Some of the dying or recently killed branches should be cut with a sharp knife. If the brown spots or streaks described are visible in the sapwood, a few twigs about the size and shape of a lead pencil are cut from fresh green wood; these specimens should show the brownish discolorations. If possible, a few leaves from the same tree should be enclosed with the twigs. A note showing the exact location of the diseased tree, of the city or town, street and number, and name of person desiring information should accompany the package. Any information as to the exact location of diseased trees may be of considerable assistance in eradicating or keeping the disease under control. The package should bear the name of the sender. If specimens are taken from more than one tree, they should be kept separate and marked in such a way that they may be distinguished. Specimens for diagnosis may be mailed to the Department of Plant Pathology, New York State College of Agriculture, Ithaca, New York, or to the nearest Dutch Elm Disease Laboratory of the United States Department of Agriculture.

CAUSE OF THE DISEASE

The Dutch elm disease is caused by a fungus pathogen, *Ceratostomella ulmi* (Schwarz) Buisman, which has an imperfect stage known as *Graphium ulmi* Schwarz. The imperfect stage was the one first discovered, and frequent references to the fungus under this name are found in writings on the subject. The organism is related to a group of fungi some of which cause discoloration in cut lumber and logs by reason of their ability to

grow within the minute cells of woody tissues without destroying them. The elm fungus is one of the few members of the group which is parasitic on living plants.

The fungus is found fruiting on dead wood of trees that have been killed by the disease. The fruiting bodies (coremia) occur only in sheltered places in cracks between wood and bark, and particularly in the galleries or channels formed by insects beneath the bark. It is for this reason that insects play so important a part in the spread of the disease. The coremia are small club-shaped structures about 1/16 inch high, having a dark stalk and a white or cream colored mass of sticky spores at the top. The spores are exceedingly minute and occur in enormous numbers. Although produced under moist conditions, the spores will endure several weeks in a very dry state. Apparently the fungus cannot enter the tree through uninjured bark. The present evidence would indicate that the spores are carried mostly by insects, and gain entrance into the living tissues of the tree through wounds caused by the feeding insects.

In a suitable environment the spores germinate and the microscopic thread-like filaments of the fungus grow into the sapwood of the elm twig or branch next to the bark. The activity of the fungus causes the deposition of the brownish substance which is so important in the recognition of the disease. The effect on the invaded twig is to cause immediate wilting of the attached leaves. The fruiting bodies, or coremia, are very inconspicuous and are of no practical assistance in identifying the trouble.

RELATION OF BARK-BEETLES TO THE DISEASE

At present it is believed that two small European bark-beetles are the principal agents by which the spores of the fungus are carried from tree to tree. The larger of these two beetles, *Scolytus scolytus* Fab., is not known to be established in this country, although it has been found in elm logs imported from Europe. The smaller one, *Scolytus multistriatus* Marsh, was first found in Massachusetts in 1909, and the evidence indicated it had already been in the country for several years prior to that time. It is now thoroughly established in numbers over southern New England, in the Hudson Valley in New York as far north as Albany, in New Jersey and south to the southern boundary of Virginia. How much more widely the insect is distributed is a matter of conjecture at the present time.

FIGURE 4. THE SMALLER EUROPEAN BARK-BEETLE
Much enlarged

FIGURE 5. THE GRUB OF THE EUROPEAN BARK-BEETLE
Much enlarged

This tiny bark-beetle is reddish-black and from 1/10 to 1/8 inch in length. The female is larger than the male and has prominent tooth-like projections at the posterior end of the abdomen (figure 4). The grub is white, is without legs, and is about 1/8 inch long (figure 5). When in a natural position, the body of the grub, or larva, is more or less curved.

Life history of the smaller European bark-beetle

The beetles attack, for the most part, sickly and dying elms by boring small holes through the bark to the sapwood. Here each female excavates a brood gallery, from 1 to 2 inches in length, longitudinally along the trunk, partly in the sapwood and partly in the inner bark. Along the sides of this gallery white eggs, from 80 to 140 in number, are deposited. As each hatches, the grub mines its own burrow to the right or to the left as the case may be. The brood gallery, with its completed larval burrows, forms on the sapwood a characteristic engraving (figure 6). When many beetles attack one tree, the galleries of the beetles and of the grubs girdle the trunk and separate the bark from the wood. The grubs transform into beetles which leave the trees through small shot-like holes in the bark. Thus the bark of infested trees becomes perforated with "shot-holes". In addition, a reddish sawdust is thrown out of these holes by the beetles, and may be seen on the outside of the bark.

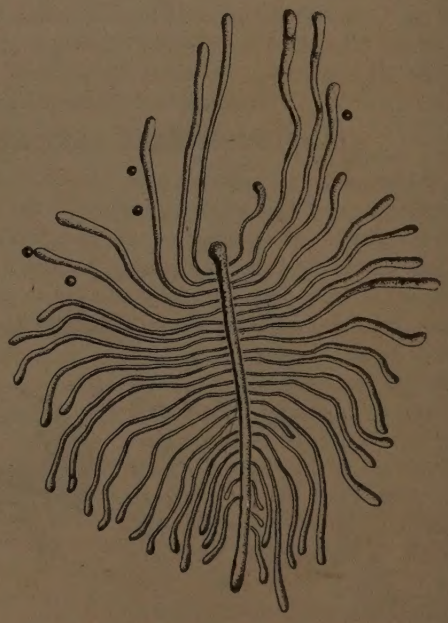

FIGURE 6. THE ENGRAVING ON THE SAPWOOD MADE BY THE BEETLE AND ITS GRUBS

Present information indicates that there are normally two broods a year in New York. The beetles first appear in May and deposit their eggs in late May and early June, while the second brood probably appear and lay their eggs in late August and early September. The grubs of this second generation pass the winter under the bark and transform to beetles in the spring.

How the beetles spread the disease

As stated, masses of spores of the causal fungus are produced on short stalks under the bark of the elm and in the galleries of the bark-beetles. When a beetle emerges from the galleries its body becomes smeared with the spores. It follows, that when the adult beetles leave the trees infected with the disease and fly to other trees, they carry the spores with them. The beetles show a preference for feeding on healthy vigorous elms. They feed on the tender tissues in the axils of the leaves, and in the crotches of the smaller twigs, and on the fresh buds. A feeding scar is shown in figure 7. During the course of such feeding, spores of the fungus lodged on the bodies of the insects are deposited in the wounds of the bark. Here the spores find conditions suitable for germination, and thus another new infection is started.

FIGURE 7. A FEEDING SCAR MADE BY A BEETLE IN THE CROTCH OF A HEALTHY ELM TWIG

Some native beetles that may carry the fungus

Several native beetles attack the elm and are often present in considerable numbers. Some of these beetles have habits similar to those of the European bark-beetle, for their grubs burrow just beneath the bark. They are therefore under grave suspicion as possible vectors, or carriers, of the disease. It is highly important that this possibility be investigated at an early date.

The dark elm bark-beetle, *Hylurgopinus rufipes* Eich., attacks the elm and basswood. It works under the bark of elms, where it makes characteristic brood galleries and larval burrows. The brood gallery runs transversely across the grain of the wood. The beetle is brownish black in color and about 1/10 inch in length.

The black elm snout-beetle, *Magdalis barbita* Say., also burrows beneath

the bark of elms. The beetle is black, with a stout abdomen and a comparatively long snout. The female is only about 1/4 inch in length. Each white grub makes a longitudinal gallery under the bark about 1½ inches long. A closely related, reddish, more slender snout-beetle, *Magdalis armicollis* Say., infests elms in a similar manner.

The elm borer, *Saperda tridentata* Oliv., is probably the most injurious borer in the American elm. The beetle is about 1/2 inch long, grayish or fawn-colored, with each wing cover marked with three orange-red transverse oblique lines and an orange line near the edge. The grub is white and about 1⅛ inches in length. The grubs form shallow burrows just under the bark and often girdle the tree.

CONTROL OF THE DISEASE

Control by eradication

The first outbreak of the disease in this country, that in Ohio, was apparently successfully checked by the prompt and complete eradication of all known infected trees. There seems little doubt that this method was satisfactory under the conditions which then existed in Ohio. There appears to be no direct connection between the present outbreak and the first one in the Middle West. It is natural, therefore, that eradication should be thought of as the first step in the present program. An eradication campaign is already under way, and every effort is being made to destroy all trees affected by the disease. In support of this work, interested persons can render valuable assistance by cooperating in every possible way with the authorities who have the eradication program in charge. Reporting the discovery of suspected trees by the method of sampling described may enable the workers to eliminate an isolated diseased tree before it becomes the center of a new group of diseased individuals. The fact that a great proportion of the trees now known to be diseased became infected in 1933, indicates how rapidly the disease has spread in the short time that it has been established.

As now carried on, eradication involves the cutting and complete removal of all the above-ground parts of the infected tree and their destruction by burning. All leaves, twigs, chips, and other debris are destroyed, and the stump is removed or, having been cut well below the surface of the ground, is stripped of its bark and covered with soil. Thus all parts of the tree which might harbor the fungus or its insect carrier are destroyed.

The success of the present eradication campaign is by no means assured. The number of known affected trees is much greater than in the former outbreak (Ohio). Perhaps more significant is the fact that the important insect carrier of the fungus is known to be well established not only in places where the disease has been found but also in adjacent areas. None of the

known insect carriers was found in Ohio during the time of the outbreak there. The success of any such eradication campaign depends essentially upon two factors, the prompt location and recognition of the disease in every place where it exists, and the immediate and effective destruction of all diseased parts and insect carriers which have been in contact with the fungus. It remains to be seen whether these requirements can be met in the present situation.

Protective measures

It is well established that the Dutch elm disease is spread largely by bark-beetles which lay their eggs in weak or dying elm trees. It follows that an important step in the control of the disease is to keep the trees in vigorous condition so that the amount of dead or dying wood which the beetles may infest is reduced to the minimum. Anything which may be done prior to the advent of the disease in a given locality to prepare the elm tree to withstand the attack of the beetle or the fungus is well worth considering. It should be noted that, while the maintenance of health and vigor in a tree will tend to discourage the egg-laying activities of the beetle, the insects feeding may, on the other hand, be encouraged, possibly with disastrous results if diseased trees are near-by. This emphasizes the importance of early recognition and removal of all trees affected with the disease.

Among the conditions which contribute to weak growth and lack of vigor of elms and other trees are: (1) leakage from gas mains, (2) defoliation by insects and diseases, (3) insufficient water supply, and (4) lack of fertility of the soil.

The symptoms of gas injury are yellowing of the foliage, generally weak growth, stag head, and scaling of the bark from the trunk. If these symptoms are apparent on trees planted near gas mains, the soil should be tested for gas leaks and the leaks should be stopped.

The numerous leaf spots of elm which frequently cause defoliation, with its accompanying weakening effect, may be controlled by three to five applications of an ordinary copper or sulfur fungicide, such as Bordeaux mixture (4–4–50), sulfur dust, wetable sulfur sprays, and the like. To be most effective these sprays should be applied about the middle of May, or whenever the buds start to open, with repeated applications at intervals of 10 to 14 days during the first part of the growing season. For elm leaf beetle and other insects destroying the foliage, spraying with arsenate of lead as soon as the insects appear in the spring is recommended. It is, of course, recognized that spraying large elm trees is not practical for the individual home owner. Such spraying might well be carried on by city foresters or other municipal or village agencies.

Pruning

Weak trees or branches showing suspicious symptoms should receive special attention, and all dead or dying branches should be removed from the trees and burned. This is important. The necessary pruning to eliminate dead and weak branches should be done in the fall, winter, or early spring to destroy the beetles before they emerge. The beetles emerge in early May in northern and western New York and several weeks earlier in the lower Hudson Valley. Wounds made in pruning should be protected with a covering of paint or other wound dressing to prevent decay.

Watering

Any condition that tends to restrict the root system of a tree or to change the level of the ground water may cause injury by cutting down the available water supply. In the construction of sidewalks or buildings, care should be used not to sever or otherwise mutilate the larger tree roots. If these roots have already been cut, the damage cannot be wholly repaired, but the trees can be benefited in time of severe drought by supplying water to the root system that remains. Some street trees have their roots covered in large part by paving. This may or may not be injurious, depending upon the proportion of the root system covered and upon soil conditions. In times of drought such trees should be watched with particular care for symptoms of drought injury; if drought conditions become acute, water should be supplied. In grading and drainage operations, the water relations of the elm root system are likely to be upset. In grading, the roots may be left more exposed or buried less deeply in the soil than they were, with the result that in times of drought the water supply to the tree will be inadequate. Such trees should be carefully watched, particularly during the first years following grading, and water should be supplied if drought symptoms become acute. Lowering the level of the ground-water table by drainage may seriously injure or even kill elm trees, particularly those that are old, unless water is supplied for the first few years after the change takes places or until the root system becomes adjusted to the new conditions.

In applying water it must be understood that casual surface sprinkling is of little or no value because the water does not penetrate the soil to the tree roots. If watering is to be effective, it must wet the soil to the depth of several feet. On level land this presents little difficulty, as water applied to the surface will soak in effectively in most soils. On sloping land, however, it may be necessary to apply the water in holes, or to build small temporary dams to prevent surface runoff.

Fertilizing

With elm trees grown along streets and in lawns, probably the most frequent cause of poor condition is the lack of fertility in the soil. Al-

though there is little experimental work to indicate the exact fertilizer needs of elms, the logical inference from extensive experimental work with fruit trees, from Cornell experiments with pin oaks, and from practical observation with elms, is that the greatest response is to be obtained from the use of nitrogen in some form. It has been, of course, amply demonstrated that the application of potassium and phosphorus will do no damage to elms, but on the other hand there is no evidence to show that these fertilizers will be beneficial and, where economy is a necessity, they may well be omitted.

On the basis of our present knowledge a conservative recommendation for the fertilization of elm trees growing in closely clipped lawns would be the application of some readily available nitrogenous fertilizer, such as ammonium sulfate or nitrate of soda. This should be applied at the rate of ½ pound for each inch of the diameter of the trunk at breast height; if the trunk is greater than 20 inches, an additional ¾ pound is needed for each additional inch. Since the roots of a 20-inch elm tree will have a spread of at least 1000 square feet of lawn surface, the fertilizer recommendation will mean about 10 pounds on 1000 square feet of lawn grass.

Where trees are growing in lawns such a heavy application of fertilizer may injure the grass unless precautions are taken. A method frequently used is to place the fertilizer in holes about 2 feet apart, distributed over the area where the feeding roots are located. Suitable holes may be made with a crowbar or other instrument and should be about 15 inches deep. If many trees are to be fertilized, some type of power drill is of great advantage. The total amount for the trees should be apportioned and distributed about equally in the holes made. In dry weather water should be poured abundantly into the holes to dissolve and spread the fertilizer so that it becomes effective more quickly.

The application should be so made that the fertilizer will reach the feeding roots of the tree. These extend some distance from the trunk, usually reaching out somewhat farther than the spread of the branches. The fertilizer may be applied evenly over this area, avoiding the region within a few feet of the trunk. This is a general recommendation for trees of the usual shape. For fastigiate, or tall narrow trees, like the Lombardy poplar, the spread of the branches does not indicate the lateral extent of the roots.

The method of application is very important if burning of the lawn grass is to be avoided. The crowbar method of inserting the fertilizer in holes below the grass roots as described does not hurt the grass but is slow and expensive. If temporary injury to the grass about the tree is not an important consideration, the fertilizer may be broadcast evenly over the surface of the ground under the spread of the branches and somewhat beyond.

Such injury to the grass can be reduced to the minimum by making the application in the very early spring or the late winter while the grass is dormant. Greatest injury to the grass results from an application made when the soil is comparatively dry. In any case, lawns usually recover rapidly from burning by fertilizer.

On fine lawns and golf greens the accepted full-rate application of ammonium sulfate or nitrate of soda for fertilization of the grass alone is 5 pounds for each 1000 square feet of surface. This is always watered in immediately unless applied during the cool weather of early spring when the soil is already full of water. Amounts which would be of benefit to trees, such as 10 to 15 pounds per 1000 square feet, have been used on lawns without much burning, provided the fertilizer is mixed with sand or some other good carrier which insures even distribution and provided the fertilizer is heavily watered in at once. If the lawn surface is flat, the fertilizer may be dissolved in water and applied directly during a rain.

Trees growing in grass sod that is not frequently mowed might well receive an application of an additional 20 per cent of ammonium sulfate or nitrate of soda, as rank-growing grass uses a large quantity of nitrate and thus prevents the fertilizer from reaching the tree roots.

Since the fertilizer requirements of trees vary greatly with the soil type and other conditions, there is no evidence to show that a somewhat heavier application than that recommended would be injurious to the trees or that a lighter one would not give the desired stimulation. The recommendation given should be safe and adequate as far as the trees are concerned. It can be increased or decreased in the years following the first application according to the response of the trees. It should be pointed out that old trees are usually more in need of fertilizer than are young ones. Also, it is unwise to apply readily soluble nitrogen carriers to recently planted young trees before the root system is thoroughly established because the fertilizer may injure the roots and leaves. Other nitrogen-carrying fertilizers are valuable in tree fertilization about in proportion to the nitrogen contained. Organic forms of nitrogen will require a longer time to become available to the trees but the effect may last longer. Good results have been obtained by using a mixture of organic and inorganic nitrogen, but there is no evidence that such a mixture has any advantage over the readily available inorganic forms.

The time of application of the fertilizer is apparently not of great importance, though the greatest benefit with least loss will probably be derived from application in the early spring about as the buds are breaking or just before. A late summer and an early fall application of readily available nitrogenous fertilizer might under some circumstances prolong growth in the fall and result in damage from winter injury. Organic forms

applied at this time have given good results, as there is no immediate stimulation of growth and the residual effect of the fertilizer lasts until the following season.

RECOVERY OF TREES ONCE INFECTED

Recovery of trees attacked by the Dutch elm disease appears to be a possibility. It has been observed particularly in England, where the English elm (*Ulmus campestris*) is the species chiefly concerned. Two types of recovery have been distinguished by English investigators. A few instances of complete recovery have been noted, in which it appears that all of the infected wood has died and with it the invading fungus. The brownish discolorations have disappeared, no further spread has taken place, and the tree is to all appearances free from the disease. Incomplete recovery, on the other hand, is characterized by the fact that the fungus remains alive, but dormant, in the living wood of the affected tree and the discolorations persist. It is conceivable that such trees would remain a source of danger to their neighbors. A small number of incomplete recoveries have been observed to again develop active symptoms after a year or so, but it remains in doubt whether the new infections were due to a revival of the dormant fungus in the tissues or to inoculation from without. In 1929, recovery attracted attention in Great Britain, and in 1932 it became particularly obvious when the observed recoveries greatly outnumbered the new infections. Recovery has also been observed on the continent of Europe. No cases have been recorded for American elms however; nor is it believed that the chance of recovery in that species is great enough to promise a solution of the problem in America.

TREES SUITABLE TO SUPPLANT ELMS

No one tree can take the place of the American elm. Its distinct, graceful vase-shaped form makes it useful under many conditions. It grows to a considerable height, produces shade but does not interfere with air circulation, and consequently is one of the few trees which may safely be planted close to the house. The trees listed in the following paragraphs are possible substitutes, mentioned in order of their preference. Emphasis has been placed on general desirable qualities as shade trees rather than on qualities similar to those of the elm.

The oaks

Four species of oaks are suggested. All are strong-wooded long-lived trees, comparatively free from serious diseases and insect pests. Oaks are of additional landscape value because of their brilliant late autumnal coloration.

The red oak [*Quercus borealis maxima* (Marshall) Sarg.] is probably the fastest growing, and is fairly open in its branching habit, and thus permits the use of service wires through the branches.

The white oak (*Q. alba* L.) is very slow in its growth, but ultimately it makes the finest tree of any in the group. In planting with thought to the future, this tree should be used more than it is. In branching habit it resembles the red oak.

The pin oak (*Q. palustris* Muench.) is somewhat different in habit, having a prominent central leader and many small drooping branches on the lower part of the trunk which give it a pyramidal shape. It thrives on wet soil and will grow also in drier situations.

The scarlet oak (*Q. coccinea* Muench.) will grow well on dry soils. Its dense branching habit makes it less desirable where service wires are a necessity.

The maples

The sugar maple (*Acer saccharum* Marsh.) is native throughout New York and will thrive on moist, well-drained soil. It is used everywhere under many conditions, both as a street tree and in ornamental plantings. If it has failed along streets and highways, the trouble can usually be traced to dry soil or close planting.

The Norway maple (*A. platanoides* L.) is probably the most common street tree in New York State. It is tough and vigorous, with a low dense branching habit which makes it unsuitable for street planting where electric-service wires are used. Because of its dense shade and its shallow root system, it is difficult to get grass or other plants to grow beneath it.

The Planetrees

The European planetree (*Platanus orientalis* L.) and the London planetree (*P. acerifolia* Willd.) are the European equivalents of the native buttonball or sycamore. These trees are particularly adapted to withstand trying city conditions. The bark, which is somewhat similar to that of the American sycamore has sometimes been considered objectionable because it peels or cracks off in large pieces and litters the ground beneath. The two European planetrees are used chiefly as street trees, under which conditions they appear less subject to the twig blight than does the American form.

The lindens

Three European types of linden (*Tilia cordata* Mill, *T. euchlora* Koch, and *T. vulgaris* Hayne.) have long been used for shade and street plantings. They are soft-wooded and not so durable as the oaks and hard maples, but they are all dense and oval in appearance and for this reason much

more appropriate for street and avenue planting than are the native lindens. It is true that the lindens are often troubled with borers in the nursery but their particular features in shape, density, and rapidity of growth make them good types for street and landscape use. *Tilia euchlora* is the smallest tree and has the most glossy foliage, while *T. cordata* has the smallest leaves and therefore the finest texture.

The honey locust

The honey locust (*Gleditsia triacanthos* L.), is very open and spreading in its habit of growth, and the finely divided foliage appears late in the spring and drops early in the fall. For these reasons the honey locust becomes one of the best trees for city courts or narrow streets where partial shade is desired. The tree has abundant branched thorns and its long fruit pods litter the ground in the fall. The thornless variety (inermis) is more desirable for children's playgrounds. Honey locust is not subject to the troublesome borer which so seriously attacks the common locust (*Robinia pseudacacia* L.).

The Maidenhair tree

The maidenhair tree (*Ginkgo biloba* L.), a native of Asia, is being used more and more in street and ornamental plantings because of its freedom from disease and insect pests. It has a very picturesque open form, its leaves are distinctly fanshaped, and its autumn color is a brilliant yellow. The fruits are decidedly ill-smelling, and for this reason only staminate, or male, trees should be planted.

The American ash

The American ash (*Fraxinus americana* L.), like the sugar maple, is native to all parts of New York State. It can be grown in almost any situation and will succeed in dry locations where the maple will not. It is rather dense in habit and the wood tends to be weak, so that careful pruning is required to develop a satisfactory shade tree.

As stated on page 17, however, the open fan-shaped American elm makes an ideal street tree and the trees suggested in the above list are at most only fair substitutes.

Those interested in obtaining further information on the use and care of ornamental trees are referred to Cornell Extension Bulletin 287, "Ornamental Trees for New York State—Their Landscape Value and Care," by R. W. Curtis and Donald Wyman.

The Plant Doctor

HUMAN ailments have long had the care of physicians; diseases of other animals require the services of veterinarians; and now so much is becoming known of the diseases of plants, and how to cope with these troubles, that plant doctors are in the field to take care of special crops and entire properties.

The Cornell University Agricultural Experiment Station and the Extension Service of the New York State College of Agriculture have discovered and made known the facts about many plant diseases. The following bulletins are available:

Diseases of small grains (E 157) *Kirby*

Bacterial canker of tomatoes (E 170) *Jones and Pederson*

The control of diseases and insects affecting vegetable crops (E 206) *Crosby and Chupp*

Control of diseases and insect pests of potatoes in upstate New York (E 238) *Barrus and Crosby*

The control of bacterial blight of celery by spraying and dusting (P 429) *Dye and Newhall*

The control of bottom rot of lettuce (P 535) *Townsend and Newhall*

Copper seed treatments for the control of damping-off of spinach (P 566) *Pirone, Newhall, and others*

The control of diseases and insects affecting vegetable crops on Long Island (E 278) *Crosby and Chupp*

Ask for them by number on a one-cent postcard addressed to the

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